PHOTOS BY A) JONATHAN N. BYNUM, B) JENNIFER LAMB

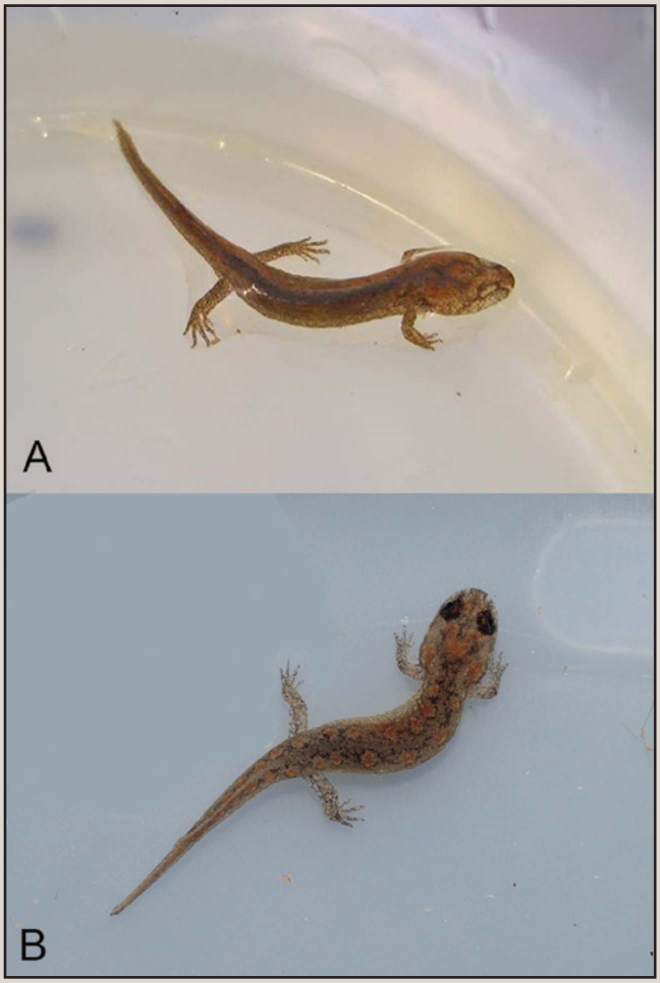

Fig. 1. A) Larval *Desmognathus conanti* with craniofacial malformations found at Bogue Chitto State Park, Louisiana, USA; B) a normal larval *D. conanti* from a similar, seep-fed stream in Mississippi.

history of lungless salamanders (Plethodontidae). Over that time, JNB and others encountered a total of 12 additional larval *D. conanti*, none of which had craniofacial or other malformations. Similarly, JYL did not observe any instances of anophthalmia or microphthalmia in larval *D. conanti* during surveys for lungless salamanders conducted in 2013–2014 at seep-fed streams in Mississippi (19 individuals across three sites).

Anophthalmia has been documented in anurans (Meteyer 2000, *op. cit.*), other lungless salamanders (*Plethodon montanus* [Northern Grey-cheeked Salamanders]; Gibson 2009. Catesbeiana 29:71–83), and in ambystomatids (*Ambystoma tigrinum* [Eastern Tiger Salamanders]; Williams et al. 2008. Biol. Lett. 4:549–552). This type of malformation seems to occur less frequently in some salamanders than do malformations of the limbs or tail (e.g., anophthalmia was seen in 0.1% of larval *A. tigrinum*; Williams et al. 2008, *op. cit.*) and may be a congenital abnormality.

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PSEUDOBRANCHUS STRIATUS **(Northern Dwarf Siren). REPRODUCTION.** Dwarf sirens (Sirenidae: *Pseudobranchus* spp.) are paedomorphic, aquatic freshwater salamanders native to the Coastal Plain of the southeastern USA. Although courtship, oviposition, and larval development have been described for *Pseudobranchus axanthus* (Southern Dwarf Siren), the reproductive life history of *P. striatus* (Northern Dwarf Siren) is poorly known (Moler 2019. *In* Krysko et al. [eds.] Amphibians and Reptiles of Florida, pp. 124–128. University of Florida Press, Gainesville, Florida. 706 pp.). Based on observations in captivity, female *P. striatus* deposit eggs singly or in small clumps, attaching the adherent eggs to vegetation; hatchlings measure 1.3–1.5 cm total length (Pfaff and Vause 2002. Herpetol. Rev. 33:42–44). Larval *P. striatus* reach 2.0 cm total length (Altig and McDiarmid, 2015. Handbook of Larval Amphibians of the United States and Canada. Cornell University Press, Ithaca, New York. 345 pp.). Here, we report observations relative to the period of reproduction for *P. striatus* in southern Georgia, USA.

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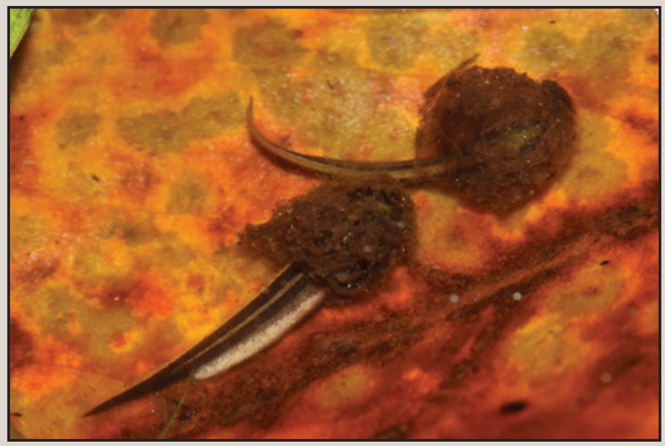

Fig. 1. Larval *Pseudobranchus striatus* in the process of hatching, Wayne County, Georgia, USA.

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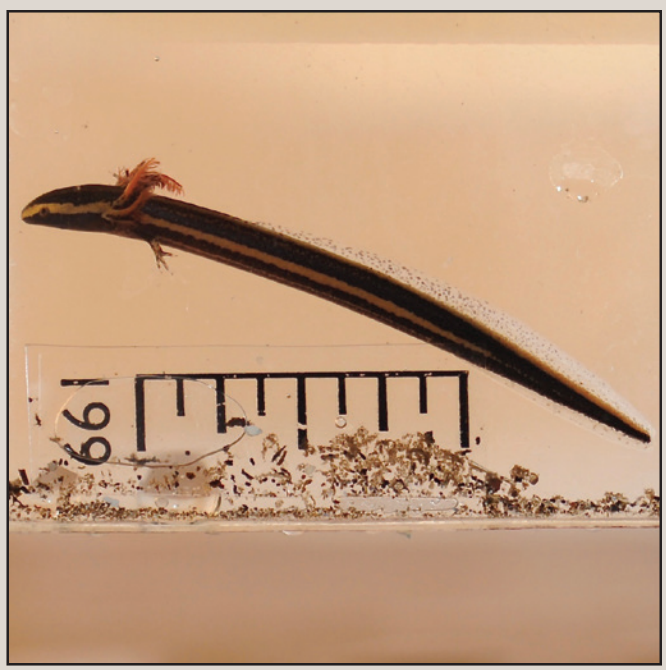

Fig. 2. Larval *Pseudobranchus striatus*, Liberty County, Georgia, USA.

Table 1. Records of *Pseudobranchus striatus* eggs (E), larvae (L), and small juveniles (J) from Georgia, USA.

Date	County	# of E, L, J	SVL/TL (cm) and Comments	Source
3 February 2004	Lanier	1 J	TL = 5.3	this study
17 February 2003	Lanier	16 J	TL = 2.5, 2.7, 3.1, 3.5, 3.5, 3.6, 3.8, 3.8, 4.0, 4.1, 4.2, 4.2, 4.6, 5.3, 6.6, 6.7	this study
26 February 2005	Lanier	1 E	larva hatched 4/1/2005: 1.1/1.5	this study
1 March 2019	Liberty	1 J	not measured (TL = 7.5 on 1 March 2020)	this study
3–4 March 1930	Lanier	11 E	eggs laid in captivity	Noble 1930
6 March 2020	Bryan	2 E	laid in captivity, female collected 19 February 2020; eggs 3 mm in diameter	this study; UF 190890
8 March 2020	Liberty	1 J	2.8/4.2	this study
10 March 1985	Glynn	3 J	1.8/2.5, 2.4/3.5, 2.9/4.3	GSU 19789
13 March 2004	Lanier	1 J	TL = 5.0	this study
16 March 2003	Lanier	9 J	TL = 3.4, 4.2, 6.0, 6.6, 6.8, 7.0, 7.6, 7.8, 8.3	this study
17 March 2003	Lanier	2 J	TL = 6.5, 7.0	this study
21 March 1974	Bulloch	17 L	0.8/0.9, 1.3/1.5, 1.3/1.5, 1.3/1.6, 1.3/1.6, 1.3/1.6, 1.3/1.6, 1.4/1.5, 1.4/1.5, 1.4/1.6, 1.4/1.6, 1.4/1.6, 1.4/1.7, 1.4/1.7, 1.4/1.8, 1.4/1.8, 1.4/1.9	GSU 19770
8 April 2018	Wayne	2 L	TL ~ 1.5, eggs hatched when dipnetted	this study; GSU 5894
21 April 2020	Atkinson	1 L	not measured	this study
28 April 1987	Clinch	1 L, 1 J	1.1/1.5, 2.4/3.5	GSU 19821
29 April–1 May 1966	Effingham	2 J	3.8/5.7, 4.2/5.9	GSU 19723, 19724
4 May 2016	Evans	1 L	not measured	this study
10 May 1975	Echols	3 J	2.2/3.3, 2.6/3.9, 2.7/3.2	GSU 22044
28 May 1972	Effingham	1 J	2.4/2.6	GSU 22071
20 July 2020	Atkinson	3 J	4.7/7.1, 5.3/8.5, 5.7/9.4	this study; UF 191352–191354
25 October 1970	Chatham	2 J	2.8/3.7, 3.1/4.2	GSU 22065
1 November 1981	Clinch	1 J	2.6/3.8	GSU 22042

Table 2. Egg development, size (cm), and oviposition history for female *Pseudobranchus striatus* from Georgia, USA.

Date	County	SVL	Total Length	Comments	Source
27 January 2020	Wayne	6.8	–	developed eggs in ovary	UF 190372
30 January 2020	Wayne	8.6	15	developing eggs in ovary	UF 190915
30 January 2020	Wayne	7.4	12.3	developing eggs in ovary	UF 190916
30 January 2020	Wayne	6.9	10.9	developing eggs in ovary	UF 190917
24 February 2017	Miller	7.2	–	developing eggs in ovary (spheniscus)	UF 179649
28 March 1997	Charlton	6.8	–	developing eggs in ovary	UF 106446
11 April 2020	Atkinson	9.9	–	developed eggs in ovary	UF 190382
21 May 1986	Long	7.1	–	developing eggs in ovary.	UF 65623
2 June 1984	Charlton	7.6	13.2	post egg deposition	UF 56781
15 June 1984	Long	8.4	–	developed eggs in ovary	UF 56742
20 July 2020	Atkinson	8.9	15.9	post egg deposition	UF 191355
21 September 2001	Wayne	6.5	–	developing eggs in ovary	UF 128292

We compiled records of *P. striatus* eggs, larvae (≤ 2.0 cm total length) and juveniles (2.1–6.4 cm total length) found in the wild in southern Georgia (also, in the case of eggs, those oviposited in captivity soon after collection) from collections we made from 2003–2005 and 2016–2020, from museum specimens in the Georgia Southern University (GSU) Herpetology Collection (collected 1966–1987), and from one published reference (Noble 1930. Copeia 1930:52). Additionally, we dissected adult female *P. striatus* specimens in the Florida Museum of Natural History (UF) to determine dates of developing eggs and developed eggs (present in the ovary). The specimens analyzed here are predominantly *P. s. striatus*, but also include several *P. s. spheniscus*. Based on molecular genetics studies these forms represent separate mitochondrial lineages (M. Fedler, unpubl. data).

We captured *P. striatus* in a variety of lentic wetlands including limesink ponds, cypress-gum ponds, Carolina bays, blackwater swamps and roadside ditches. We measured SVL and/or total length of most individuals. Small numbers of eggs were found in the field. A female *P. striatus* from Lakeland, Georgia maintained by Noble (1930) in captivity laid 11 eggs over a 5-week period (Table 1). One egg we dipnetted in Lanier County on 26 February 2005 hatched on 1 April 2005 and 2 eggs that we dipnetted in Wayne County on 8 April 2018 hatched the same day (Fig. 1). Hatchling-sized larvae (0.9–1.9 cm total length) or juvenile (2.5–9.4 cm total length) *P. striatus* were found on 18 sampling events from 3 February–28 May 2020 at 12 different wetland sites and on two sampling events from 25 October–1 November 2020 at two sites (Figure 2; Table 1). Larger-sized juveniles (7.1–9.4 cm total length) were collected at one of these sites on 20 July 2020.

We detected developing eggs or well-developed eggs in 10 female *P. striatus* museum specimens we dissected. Eight of these females were collected from 27 January–21 May, at five different wetland sites (Table 2). A female found on 15 June contained well-developed eggs and another female collected 21 September contained developing eggs. Two specimens that we examined that were collected 2 June–20 July 2020 had recently deposited eggs (based on the presence of a few developed eggs loose (unbundled) in the enlarged ovaries and eggless enlarged oviducts; we believe this indicates that most eggs had recently been oviposited and the specimens had yet to either pass the remaining eggs or resorb them). These museum data suggest that the minimum size at reproduction for *P. striatus* may be smaller (6.5 cm SVL) than in *P. axanthus* (7.0 cm SVL).

Our data indicate that, for female *P. striatus* in southern Georgia, eggs develop in the ovary from January–October and egg deposition may occur throughout this period, with a possible hiatus in the hottest months of July and August. The data we compiled here suggests that egg deposition peaks from autumn through spring. An oviposition period of mid-June–August has been reported for captive *P. striatus* maintained in outdoor tanks in South Carolina (Pfaff and Vause 2002, *op. cit.*). In southern peninsular Florida, closely related *P. axanthus* breed year-round, with egg development requiring 16–30 days (Adcock, 2012. M.S. Thesis, University of South Florida, Tampa, Florida. 70 pp.). Adcock (2012, *op. cit.*) suggested that *P. axanthus* breed year-round as long as surface water is present, and that reproduction may be stimulated by rainfall. An autumn–spring breeding period for *P. striatus* in southern Georgia corresponds to the period when the basins of isolated, ephemeral ponds and other temporary or semi-permanent wetland habitat types used by *P. striatus* become inundated (Wharton 1978. The Natural Environments of Georgia. Georgia Department of Natural Resources, Atlanta, Georgia. 227 pp.).

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***TARICHA GRANULOSA* (Rough-Skinned Newt). PREDATION.** We found skeletal remains of fully digested *Taricha granulosa* in the stomach contents of four free-ranging, presumably healthy *Strix varia* (Barred Owl) collected from Roseburg, Oregon, USA (Table 1). This study recorded stomach contents from over 1300 *S. varia* collected as part of a lethal removal experiment in localities near Cle Elum, Washington; Alsea, Oregon; and Roseburg, Oregon. In the stomach of one *S. varia*, we identified the remains of 14 individual *T. granulosa*. There have been two previous records of predation on *T. granulosa* by *S. varia*, both in northern California. An undigested *T. granulosa* was identified from the stomach of a single *S. varia* found dead and salvaged, and two partially digested *T. granulosa* were identified in a live, seemingly healthy, *S. varia*, that was subsequently shot and collected as part of a lethal removal experiment (Medina et al. 2018. Wilson J. Ornithol. 130:780–783).

Taricha granulosa produce a lethal neurotoxin in the granular glands of the skin that along with aposematic markings and behaviors, provides a defense against predators. When ingested, tetrodotoxin (TTX) blocks the voltage-gated sodium channels causing muscle weakness, convulsions, paralysis, and death. This defense mechanism is an effective deterrent to predation throughout their range from California to Alaska, with the notable exception of *Thamnophis sirtalis* (Common Garter Snake) that has evolved resistance to this toxin in some portions of their range (Brodie and Brodie 1990. Evolution 44:651–659). This TTX resistance in some *T. sirtalis* populations has led to an evolutionary arms race between *T. sirtalis* and *T. granulosa*, resulting in a patchwork of newt toxicity levels and snake resistance across the range where both species occur (Brodie and Brodie 2007. Evolution 56:2067–2082).

Although we cannot measure the TTX levels in digested *T. granulosa* specimens identified in *S. varia*, toxin levels are presumed to be moderate based on toxicity range maps (Hanifin et al. 2008. PLoS Biol 6:e60). Further, there are reports of apparent non-lethal predation on newts by *Lophodytes cucullatus* (Hooded Merganser) and *Lontra canadensis* (North American River Otter), but no evidence for TTX resistance pathways in birds or mammals (Stokes et al. 2015. Northwest Nat. 96:13–21;

Table 1. Skeletal remains of *Taricha granulosa* in the stomach contents of four *Strix varia*.

Date	Location (NAD83)	Sex of Owl	Age of Owl	# of Newts
4 November 2016	43.00583, -123.10137	Male	After second year	2
9 April 2018	43.06598, -123.03132	Female	First year	9
2 November 2018	42.94993, -123.07636	Female	Second year	2
3 April 2019	43.05357, -123.15277	Female	First year	14